Easy Java Simulation (EJS), an innovative tool for teacher as designers of gravity-physics computer models

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http://weelookang.blogspot.sg/2013/04/mptl18-easy-java-simulation-innovative.html

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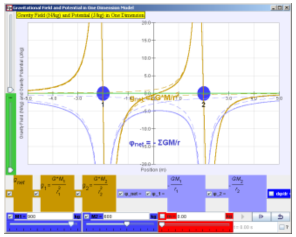
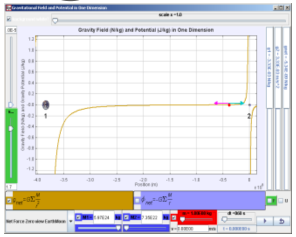
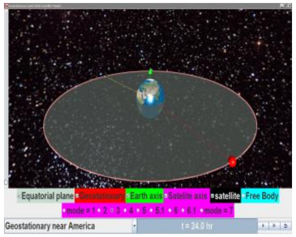
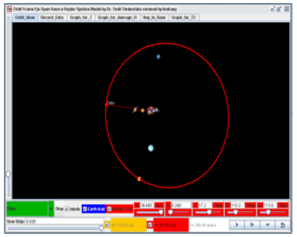
- **Digital Libraries**
  - http://www.compadre.org/OSP/
  - http://www.phy.ntnu.edu.tw/ntnujava/index.php
  - EJS itself has examples as well

1. innovativeness of EJS

- **Breakthrough in teacher education [R]**

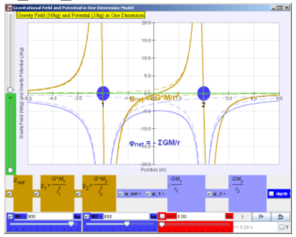
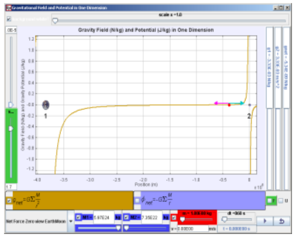
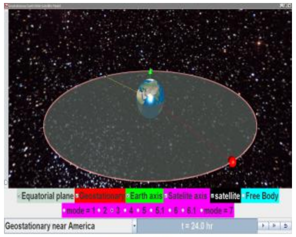
  - products (computer models)
    - Customized to SG syllabus (teacher-student feedback)
  - processes (O·S·P open source physics professional community)
    - Teacher education in OSP community
    - To benefit all humankind

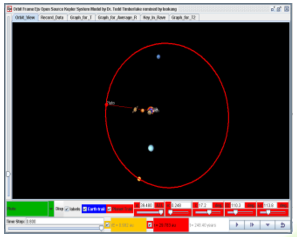
2. Rationale

- Physics is best learnt **by inquiry** through **hands-on** exploration.
- Difficult to conduct experiment [R] on topics like Gravitation in school laboratories.
- Many students **fail to visualise** the gravitational effects of huge masses and the motion of satellites.
- **Little physical meaning** to the number-crunching.

3. Design

- **Four** simulations were selected to address concepts on:
  - ***(1) Gravitational field strength and potential;***
  - ***(2) Escape velocity;***
  - ***(3) Geostationary orbit;***
  - ***(4) Kepler's Third law.***



- These simulations were infused strategically into **tutorial** questions or separately as **laboratory worksheets** to enhance students' learning.

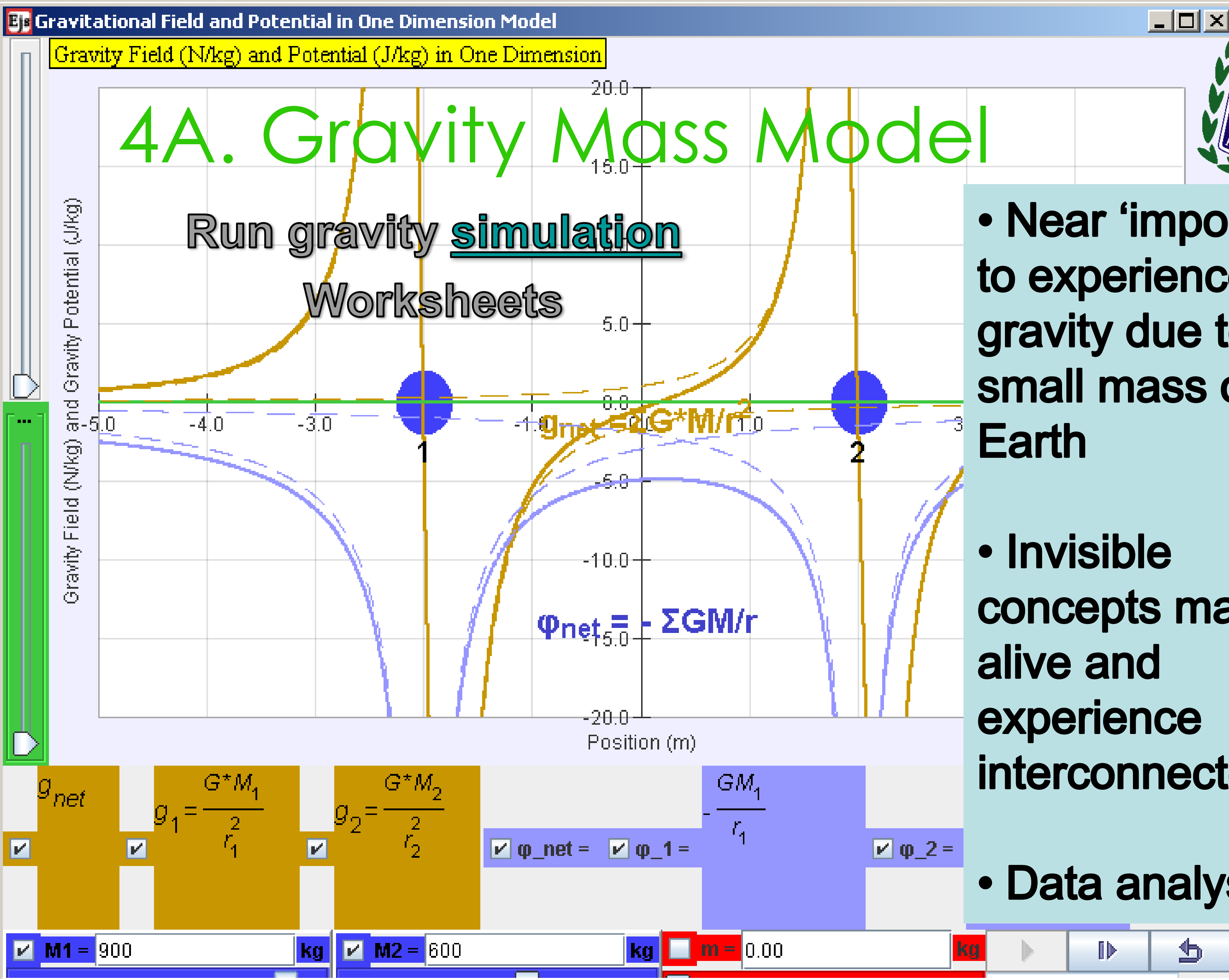
3. Design (modified 5**E** inquiry)

- Students were introduced to relevant videos and get them **e**ngaged in the simulations.
- Students **e**xplored the simulations at their own pace, guided by the worksheet questions. ***[Self-directed learning]***
- Students **e**xplained their understanding in small groups. ***[Collaborative learning]***
- Teacher asked questions to get students to **e**laborate their understanding.
- Selected groups did class presentation and **e**valuate what they have learnt.

4A. Gravity Mass Model

Run gravity simulation

Worksheets



- Near 'impossible' to experience gravity due to small mass on Earth
- Invisible concepts made alive and experience interconnected
- Data analysis

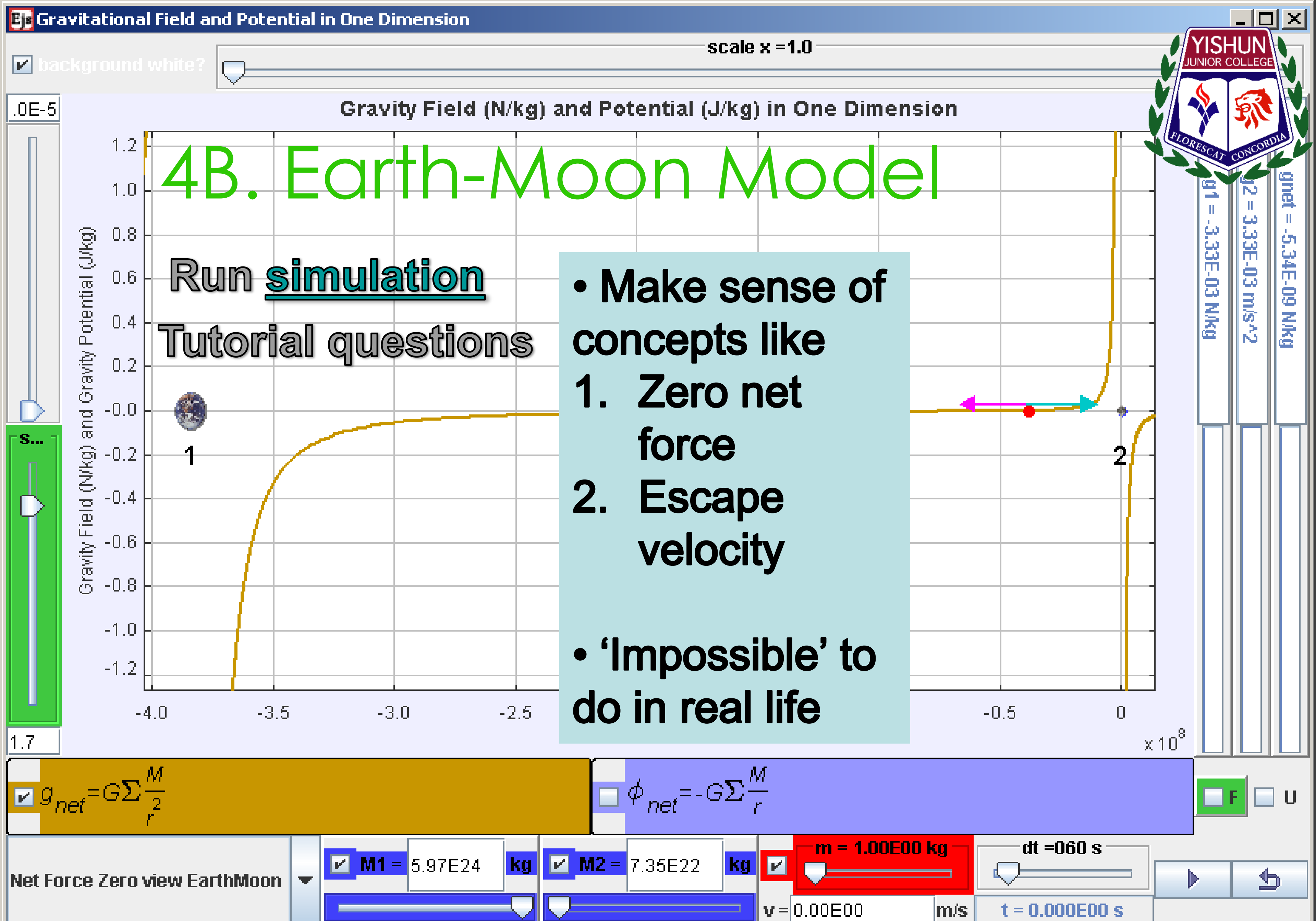
Derived work based on Andrew Duffy's earlier electric charge model

4B. Earth-Moon Model

Run simulation

Tutorial questions

- Make sense of concepts like
  1. Zero net force
  2. Escape velocity
- 'Impossible' to do in real life



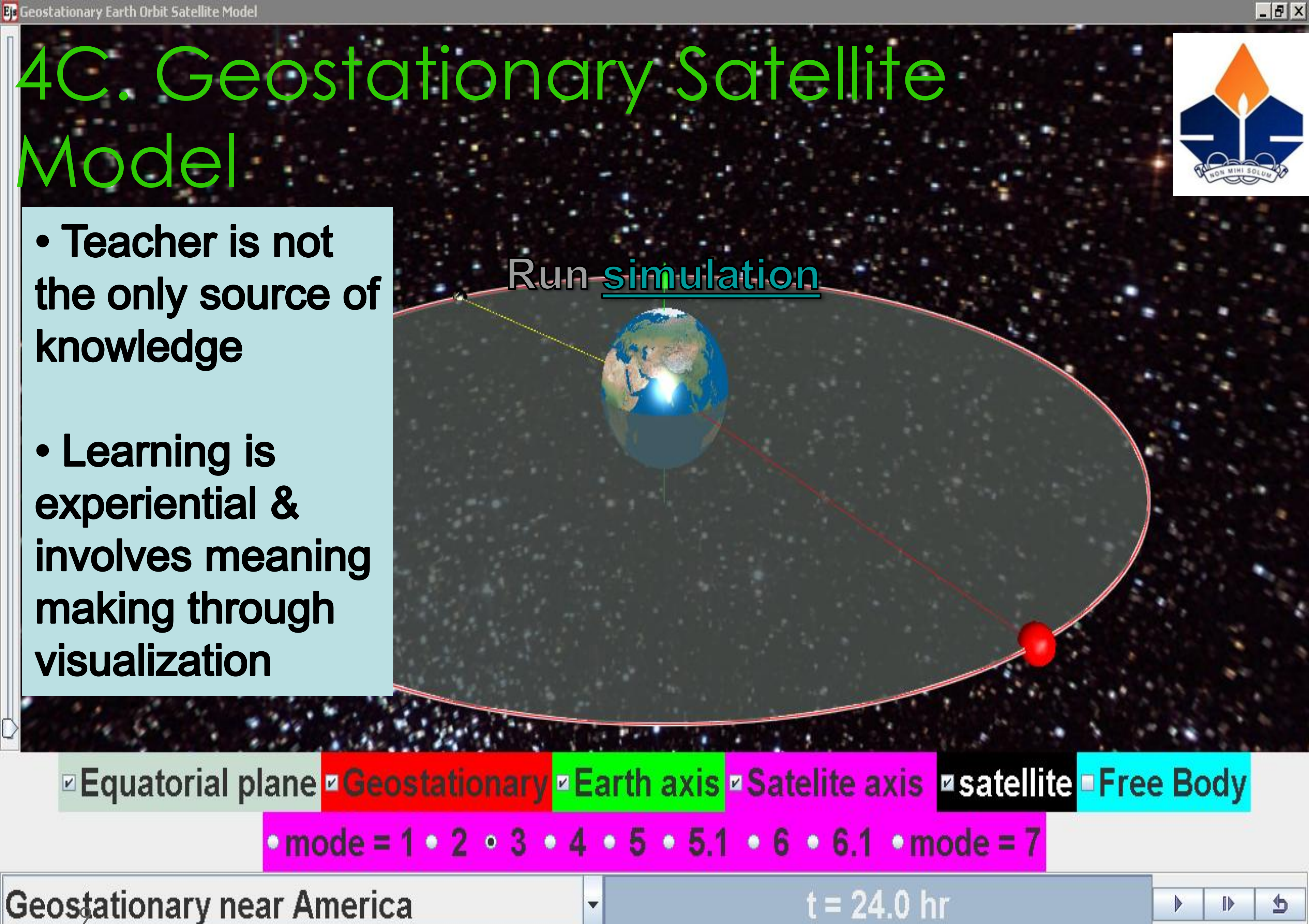
Derived work based on Andrew Duffy's earlier electric charge model

4C. Geostationary Satellite Model

- Teacher is not the only source of knowledge

- Learning is experiential & involves meaning making through visualization

Run simulation

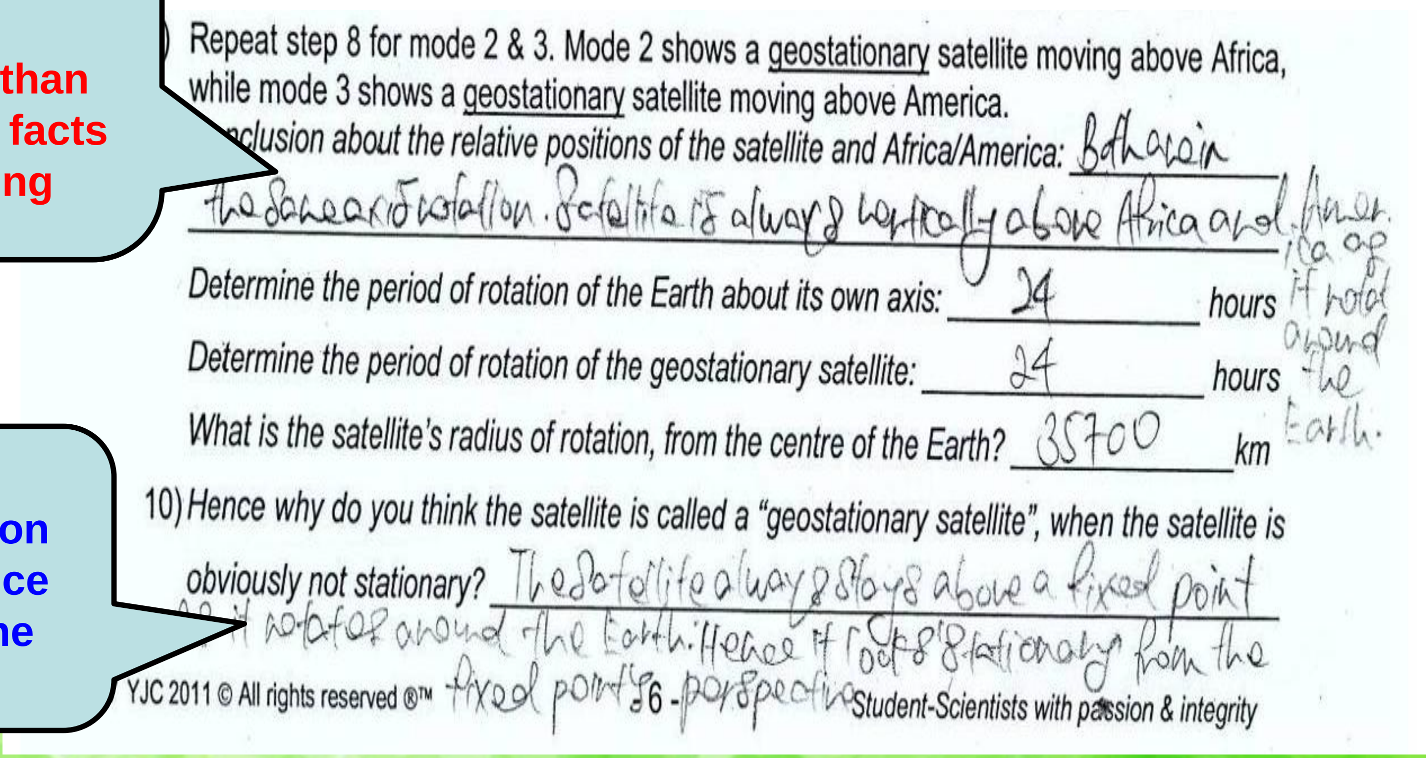


Derived work based on Francisco (Paco) Esquembre's earlier model

4C. Geostationary Satellite Model

- Create active learning previously not **possible**

The students' answers are now actually based on the acts of scientific inquiry being scientist themselves, rather than the memorization of facts (traditional teaching method).


Repeat step 8 for mode 2 & 3. Mode 2 shows a geostationary satellite moving above Africa, while mode 3 shows a geostationary satellite moving above America.

…nclusion about the relative positions of the satellite and Africa/America: Both are in the same axis of rotation. Satellite is always vertically above Africa and America as it rotates around the Earth.

Determine the period of rotation of the Earth about its own axis: 24 hours

Determine the period of rotation of the geostationary satellite: 24 hours

What is the satellite's radius of rotation, from the centre of the Earth? 35700 km

10) Hence why do you think the satellite is called a "geostationary satellite", when the satellite is obviously not stationary? The satellite always stays above a fixed point as it rotates around the Earth. Hence it looks stationary from the fixed point's perspective.

YJC 2011 © All rights reserved ®™ 6 - Student-Scientists with passion & integrity

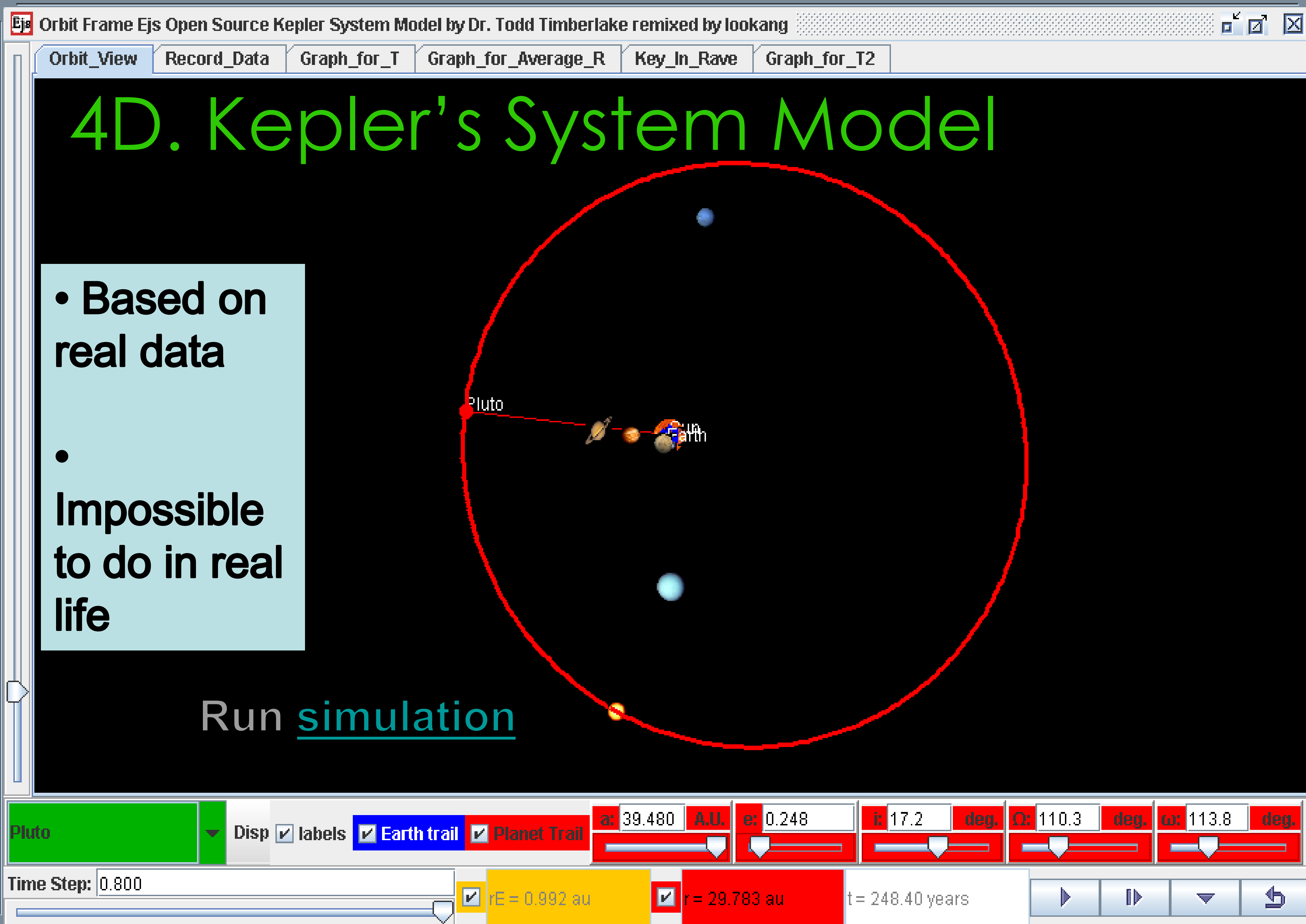
Making logical conclusions based on student-lead evidence based inquiry on the models.

4D. Kepler's System Model

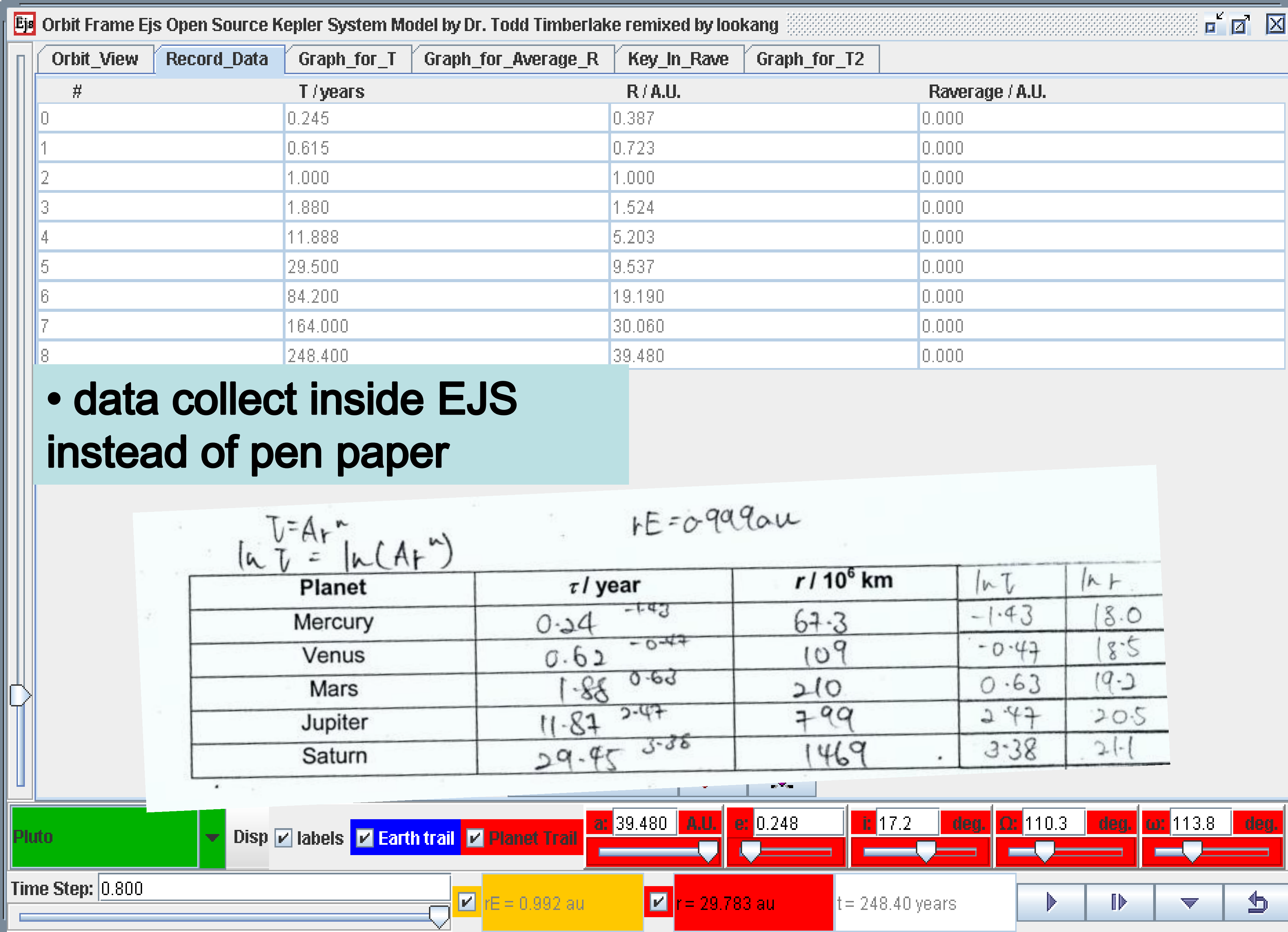
- Based on real data

- Impossible to do in real life

Run simulation



Derived work based on Todd Timberlake's earlier model



#	T / years	R / A.U.	Raverage / A.U.
0	0.245	0.387	0.000
1	0.615	0.723	0.000
2	1.000	1.000	0.000
3	1.880	1.524	0.000
4	11.888	5.203	0.000
5	29.500	9.537	0.000
6	84.200	19.190	0.000
7	164.000	30.060	0.000
8	248.400	39.480	0.000

- data collect inside EJS instead of pen paper

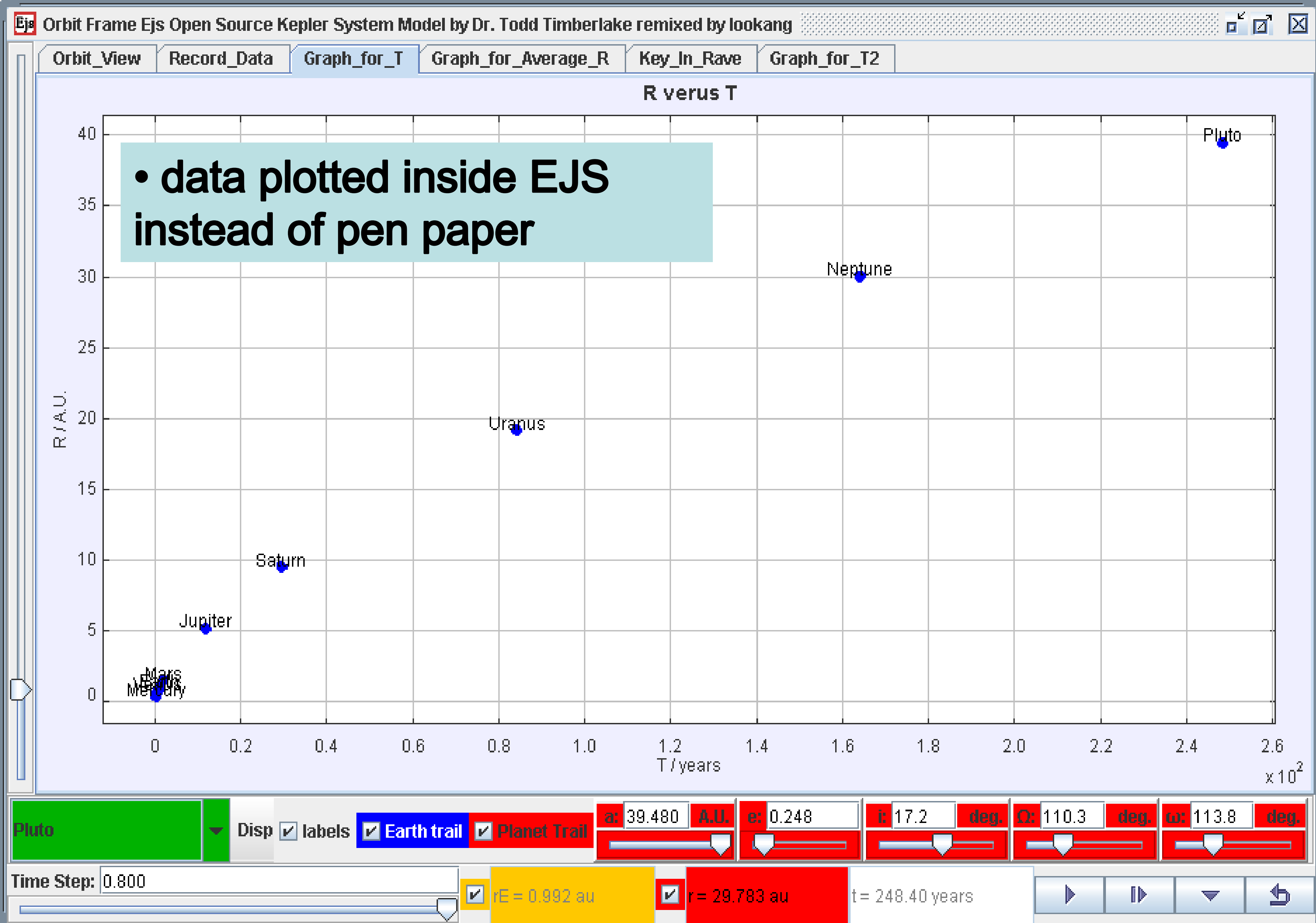
$T = Ar^n$

$\ln T = \ln(Ar^n)$

rE = 0.999 au

Planet	τ / year	r / 10^6 km	ln T	ln r
Mercury	0.24 -1.43	67.3	-1.43	18.0
Venus	0.62 -0.47	109	-0.47	18.5
Mars	1.88 0.63	210	0.63	19.2
Jupiter	11.87 2.47	799	2.47	20.5
Saturn	29.45 3.38	1469	3.38	21.1

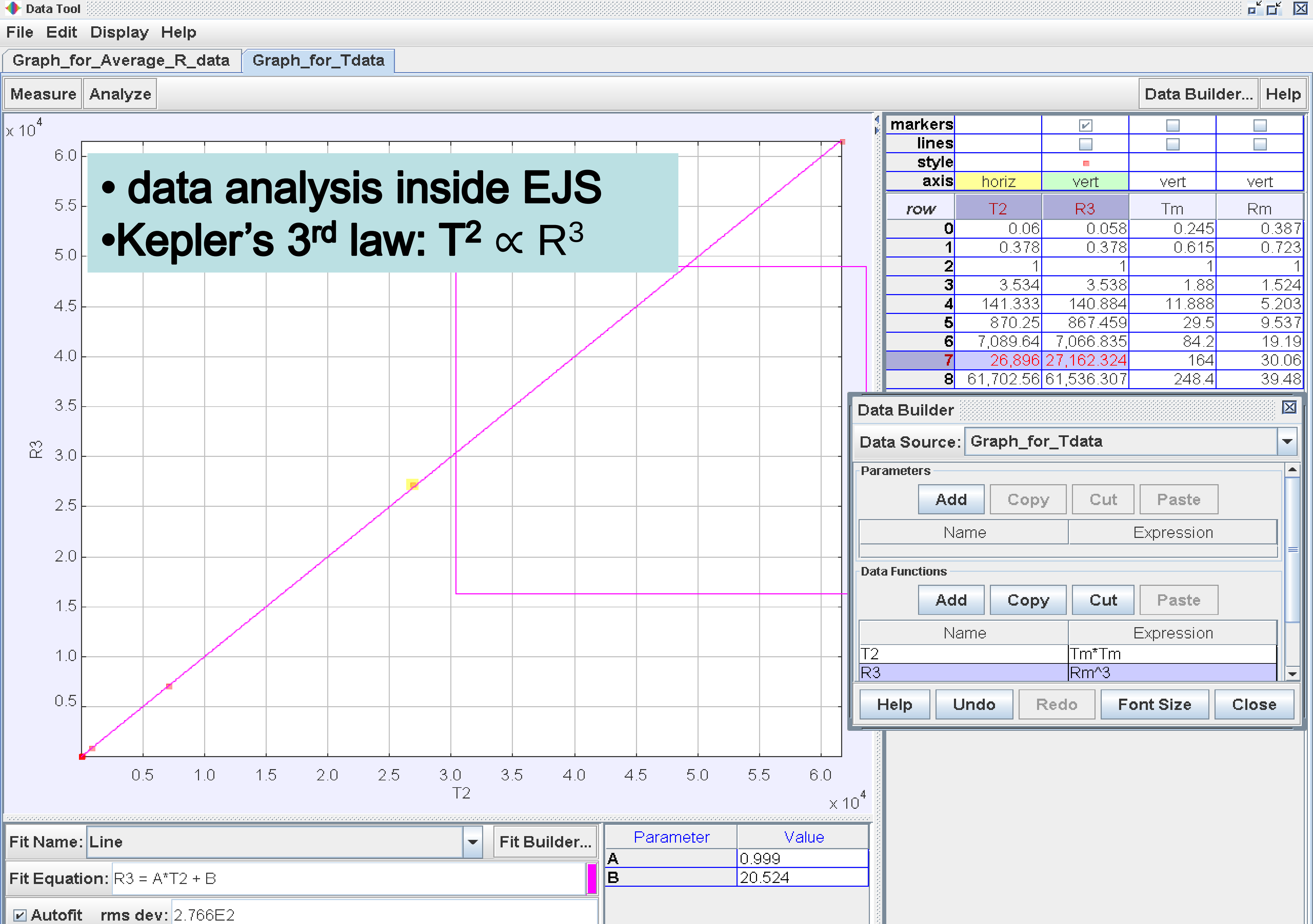
Derived work based on Todd Timberlake's earlier model



• data plotted inside EJS instead of pen paper

Derived work based on Todd Timberlake's earlier model

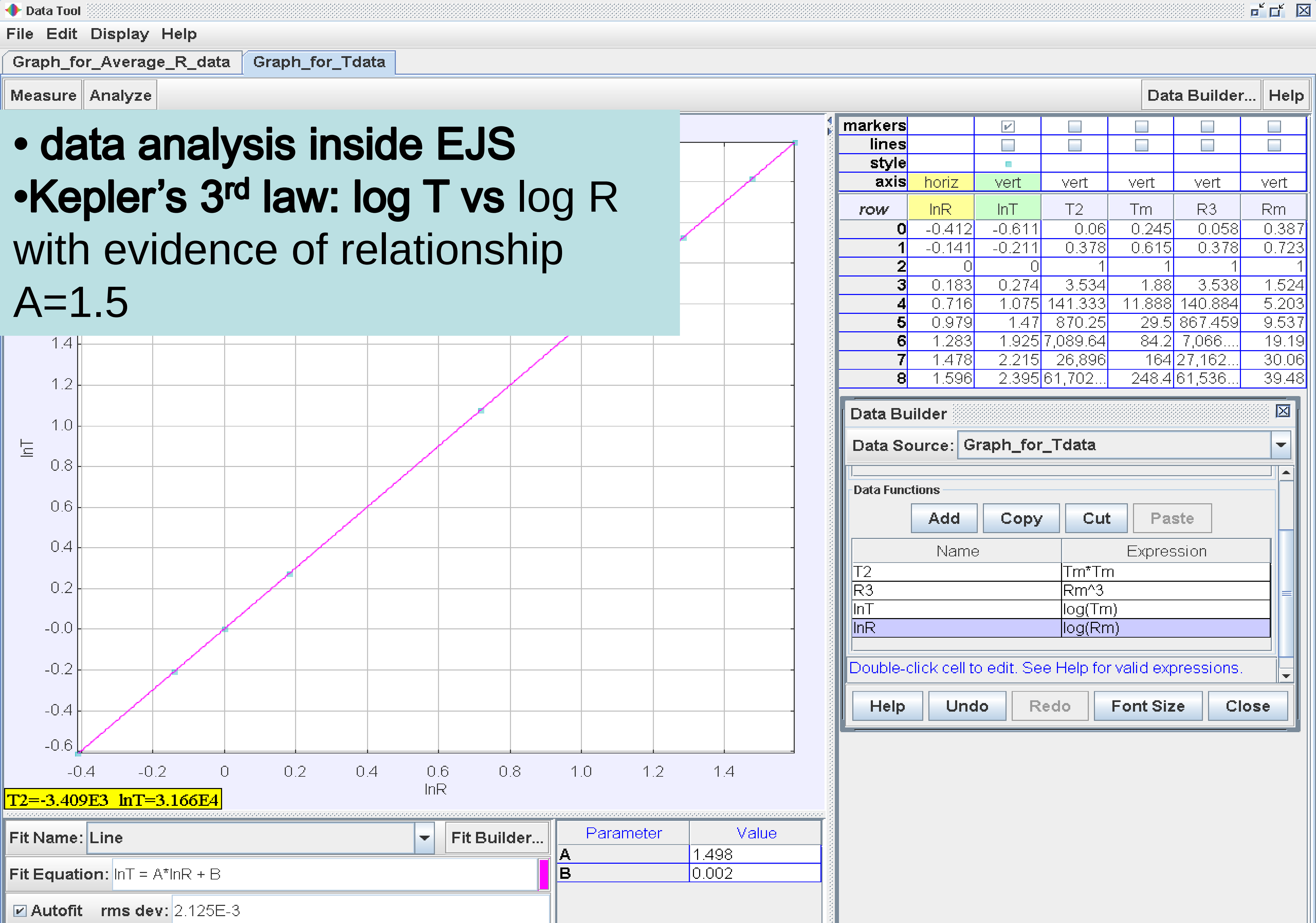
- data analysis inside EJS
- Kepler's 3rd law: $T^2 \propto R^3$



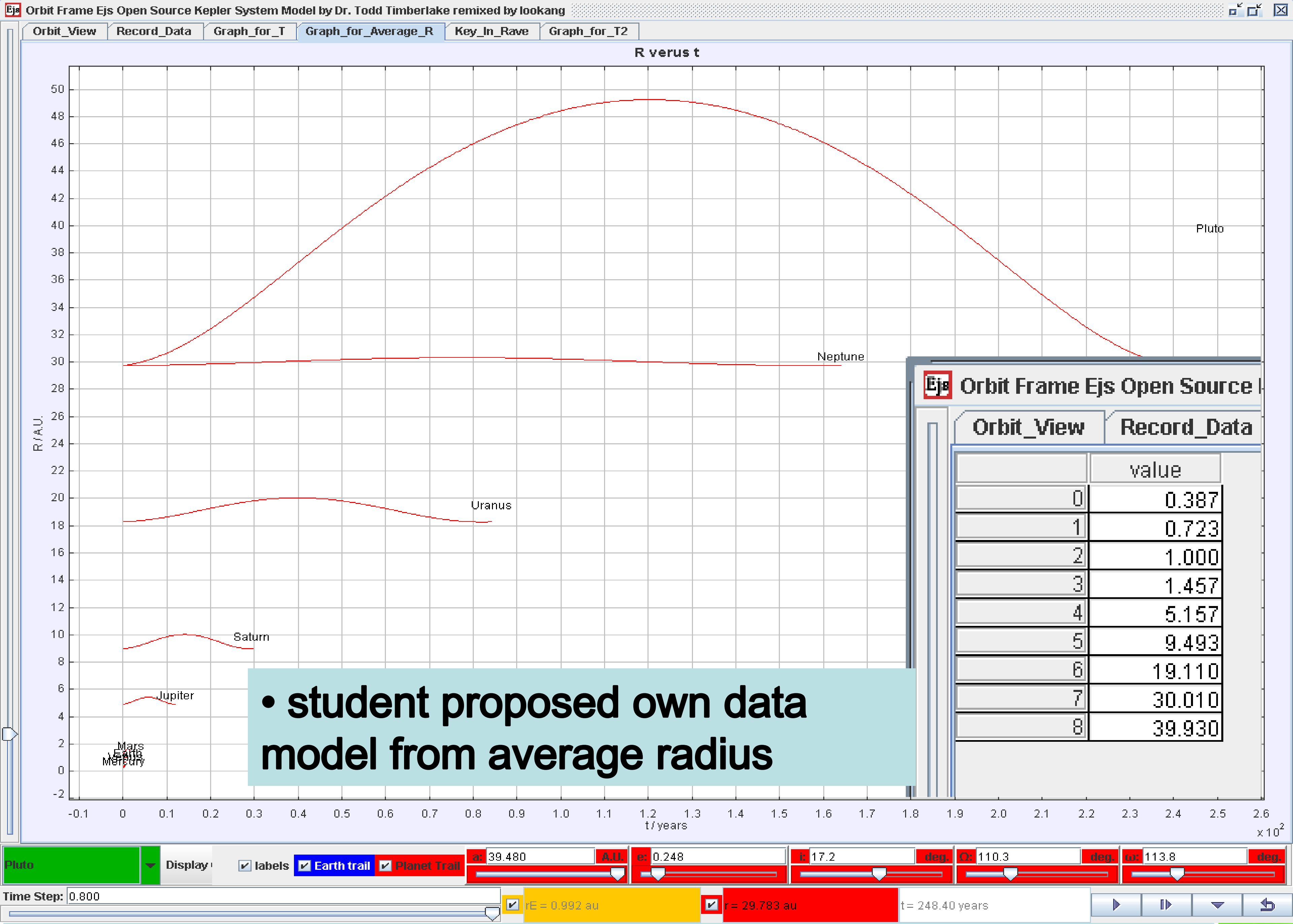
Derived work based on Todd Timberlake's earlier model

• **data analysis inside EJS**

•**Kepler's 3[rd] law: log T vs** log R with evidence of relationship A=1.5



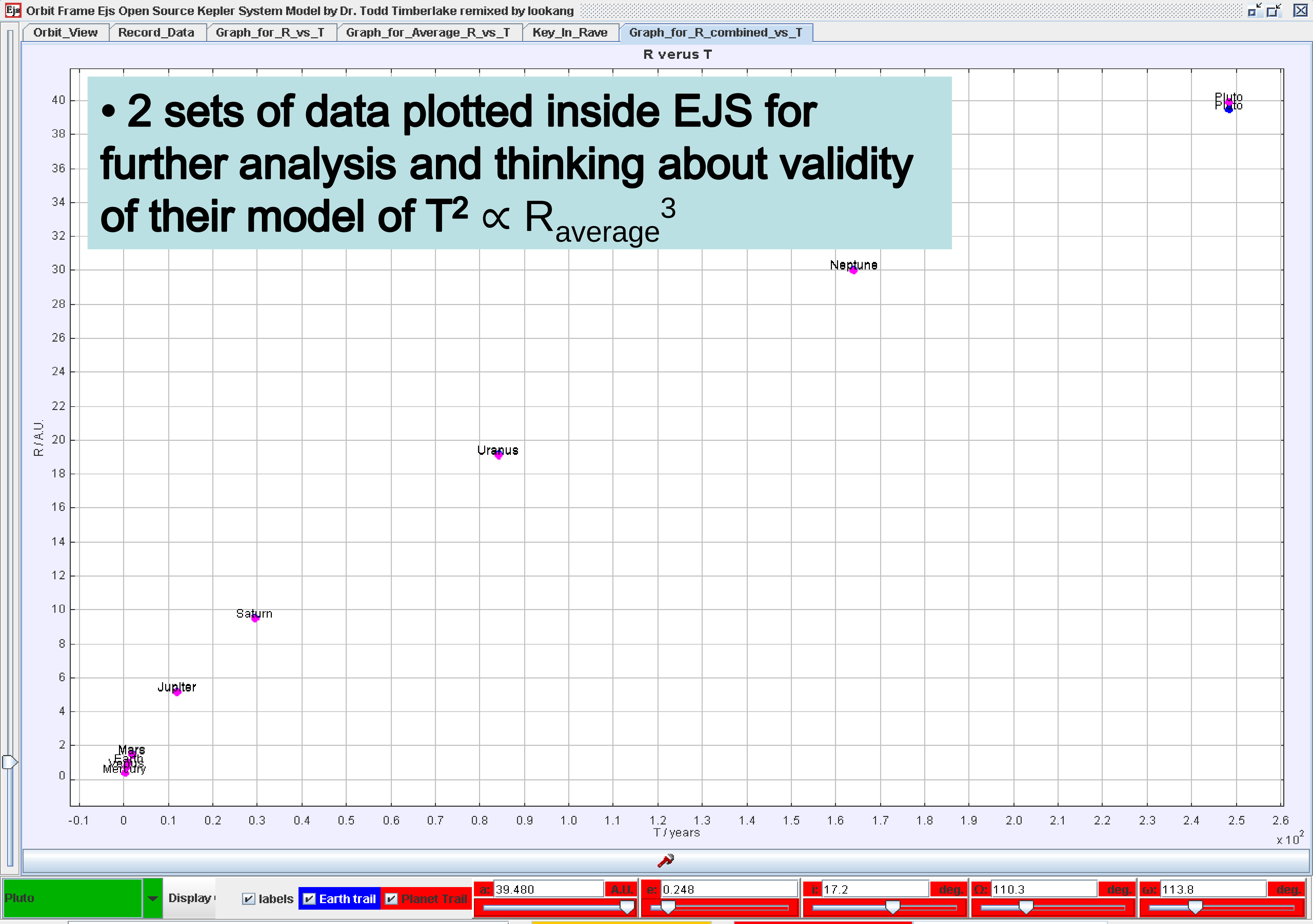
[Derived work based on Todd Timberlake's earlier model]



- student proposed own data model from average radius

Derived work based on Todd Timberlake's earlier model

• 2 sets of data plotted inside EJS for further analysis and thinking about validity of their model of $T^2 \propto R_{average}^3$



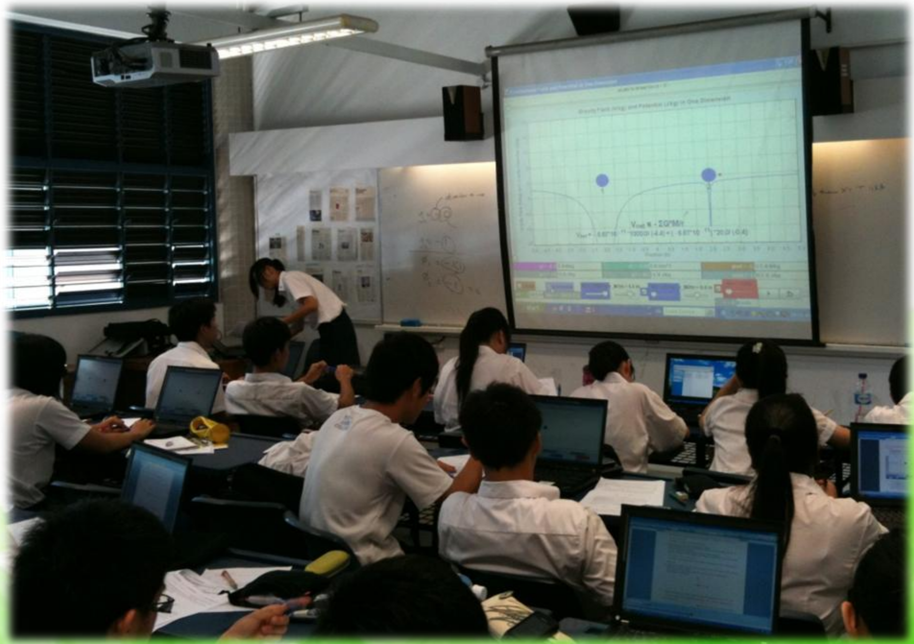
Derived work based on Todd Timberlake's earlier model

5A: Student feedback

- The EJS lessons make it easier for us to depict the motion of objects in 3D.
- The theory is now much easier to understand.
- The simulations provided interesting information beyond the syllabus.
- "I think the simulations are good as they make me view physics in a different perspective."

5B: Teacher reflection

- Help students visualise the effect of gravitation, motion of satellite, etc.
- Manipulation of parameters allows independent learning outside curriculum time.
- Curriculum time is required to guide students on the use of simulations at the initial stage.
- Worksheets questions need to be more thought-provoking.



6. we, the teachers are evidences that EJS has been an innovative tool

- Learners as “scientists”
  - Inquiry-based learning into the hands of ordinary students all over the world.

- Teachers as designers of computer models
  - 5 journal **publication** at Physics Education
  - 3 SG **local** conference papers
    - Academy Sym2011, iCTLT2012 , ICCE2012
  - 4 **overseas** conference papers
    - AAPTSM10 2010, AAPTWM12 2012, WCPE 2012, MPTL18